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VG09-052

Novel Plasticizer for IM Compliant Solid Propellants

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Approved for Public Release
09-MDA-4414 (17 APR 09)

Acknowledgement of Support and Disclaimer
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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
17 APR 2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Novel Plasticizer for IM Compliant Solid Propellants	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Physical Sciences Inc,20 New England Business Center,Andover,MA,01810**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**15**	

Physical Sciences Inc.

Physical Sciences Inc.

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- **36 year-old company of 180 talented scientists, and engineers**
- **We work in headquarters in Andover, MA, with five satellite locations in the United States**
- **Acoustics**
- **Electro-magnetics**
- **Fluid physics**
- **Life sciences**
- **Chemical sciences**
- **Energetic Materials**
- **Optical sciences**
- **Plasma physics**
- **Space physics**

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Nitrofurazan Plasticizers (NF)

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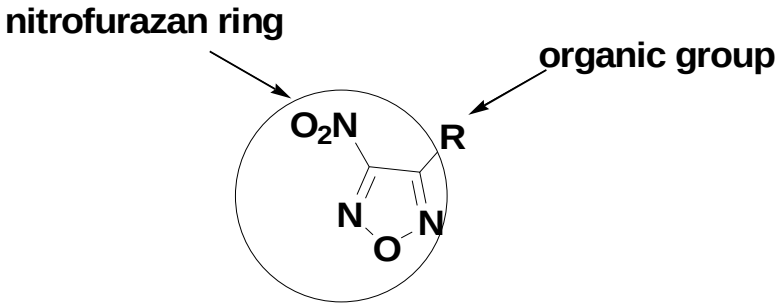
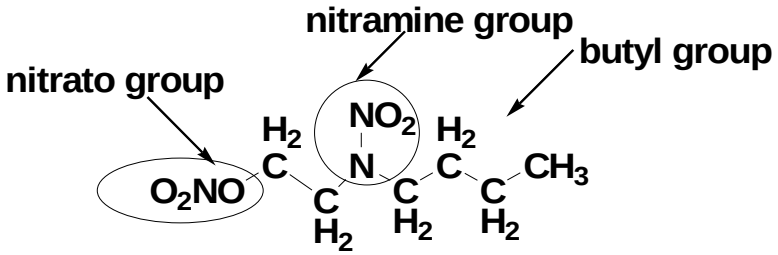
- **Nitrofurazan family offers promise as high energy, good thermal behavior, high density and low sensitivity plasticizers**



NF plasticizers



Butyl NENA plasticizer

- **NF core: heterocyclic ring with high thermal stability, good density**
- **Organic Group R: capability to functionalize the nitrofurazanic core**
- **R group variation may generate various categories of NF plasticizers**

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Background: NF1

- **PSI synthesized and characterized NF1 from low cost precursors (30% yield)**
- **Aerojet performed the energetic and thermal properties testing: promising plasticizer with good energy and good density**

	Density Gm/cc	Decomposition Temperature, ºC	ΔHf, Kcal/mol
NF1 theor	**1.620**	**180**	**69.5**
NF1 exp.	**1.467**	**180**	**58.8**
Butyl NENA	1.211	165	-45.55
TMETN	1.488	158	-105.8
BTTN	1.520	154	-92.6

Background: NF1 Cont'd

- **NF1 properties**
  - Low viscosity fluid
  - Moderate volatility
- **Measurements show it is insensitive**
  - Category "Green" [normal]

Hazard	NF1	RDX
Impact, kg-cm	145	49
Friction, psi @ drop angle, ^{o}	1800 @ 90^{o}	1200@90^{o}
ESD, J @ 5kv	6.0	0.38

Background: NF1 Cont'd

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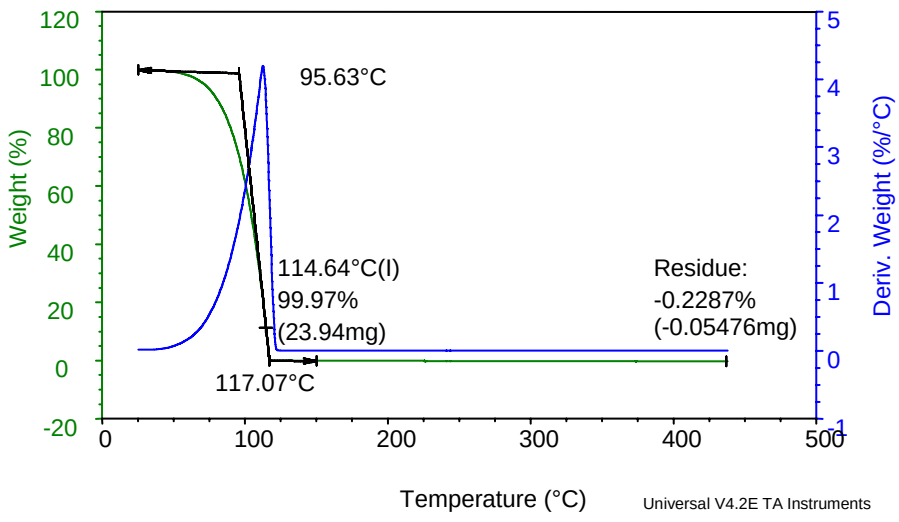

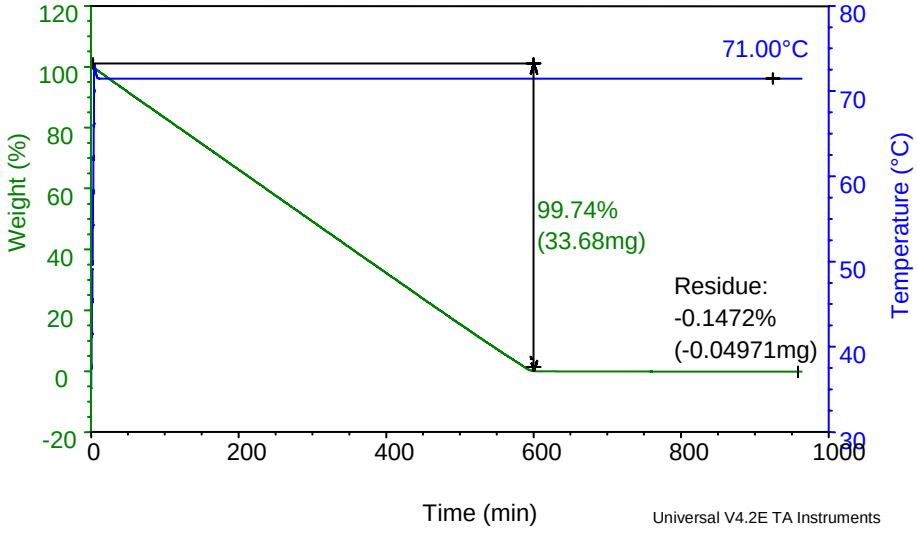

Onset of weight loss in TGA occurs at a low temperature

Isothermal TGA shows material evaporates after 10 hr at 70°C

Chemical modification to NF1 was required to eliminate volatility

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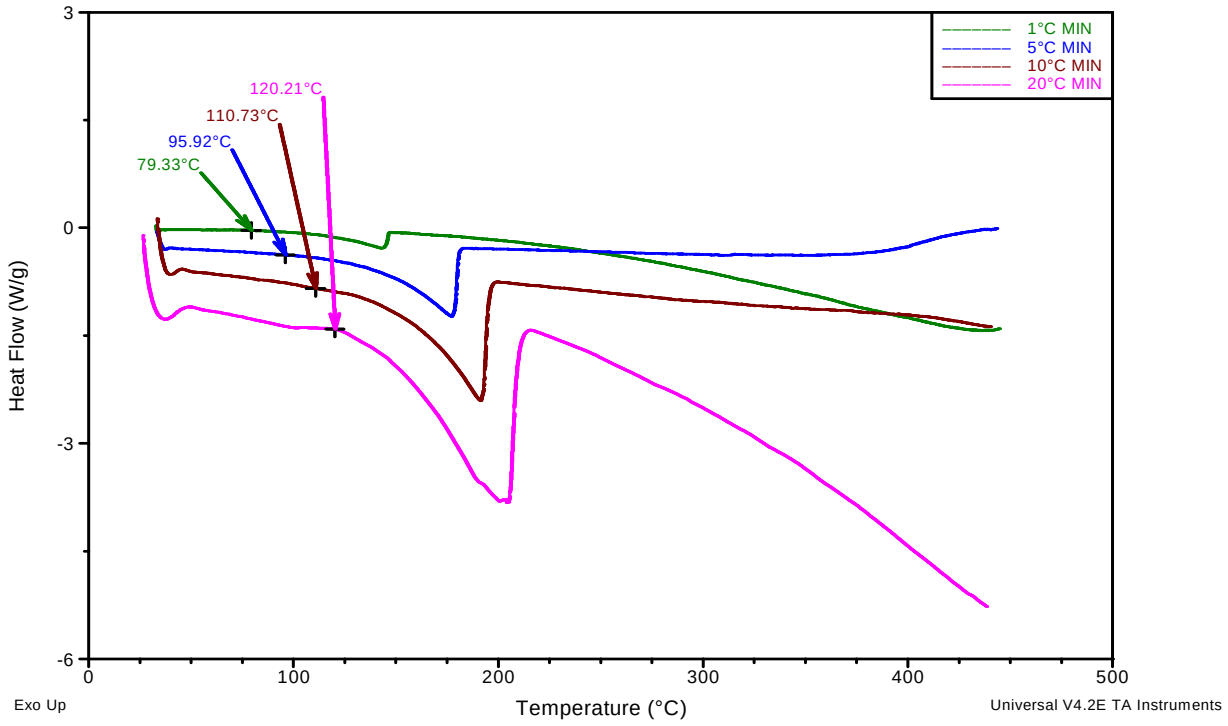
NF1: Background Cont'd



In Differential Scanning Calorimetry (DSC)
only endotherms noted due to vaporization – no exotherms

Novel Nitrofurazan Plasticizer: NF2

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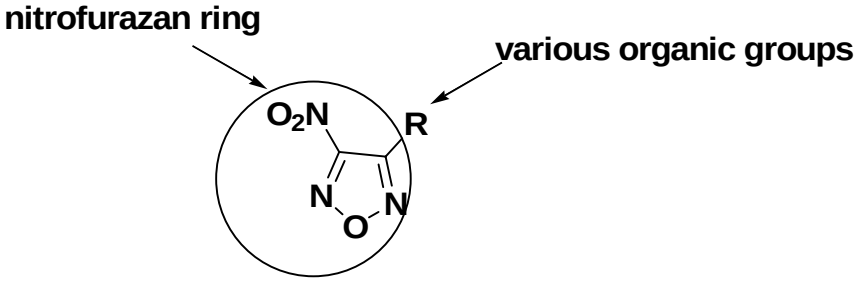
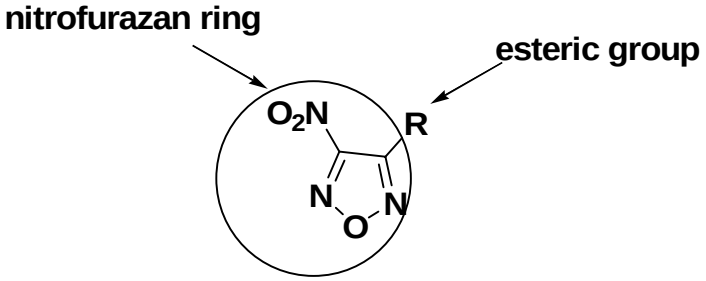
- **Variation of the R group generated various NF classes of nitrofurazanic plasticizers**
- **R = esteric group: Esteric NF Plasticizers Candidates**
- **NF2 showed good energy, good density and acceptable volatility**



NF plasticizers



NF2 plasticizer

Novel Nitrofurazan Plasticizer: NF2 Cont'd

	Density G/cm^3	Decomposition Temperature, ^{o}C	ΔHf, Kcal/mol
NF2 exp.	**1.264**	**176.4**	**-62**
NF1 exp.	**1.467**	**180**	**58.8**
Butyl NENA	1.211	165	-45.55
TMETN	1.488	158	-105.8
BTTN	1.520	154	-92.6

NF2 has good sensitivity and good thermal properties

Hazard	NF2	RDX
Impact, kg-cm	**300**	**49**
Friction, psi @ drop angle, ^{o}	**1800 @ 90^o**	**1200@90^o**
ESD, J @ 5kv	**6.0**	**0.38**

Novel Nitrofurazan Plasticizer: NF2 Cont'd

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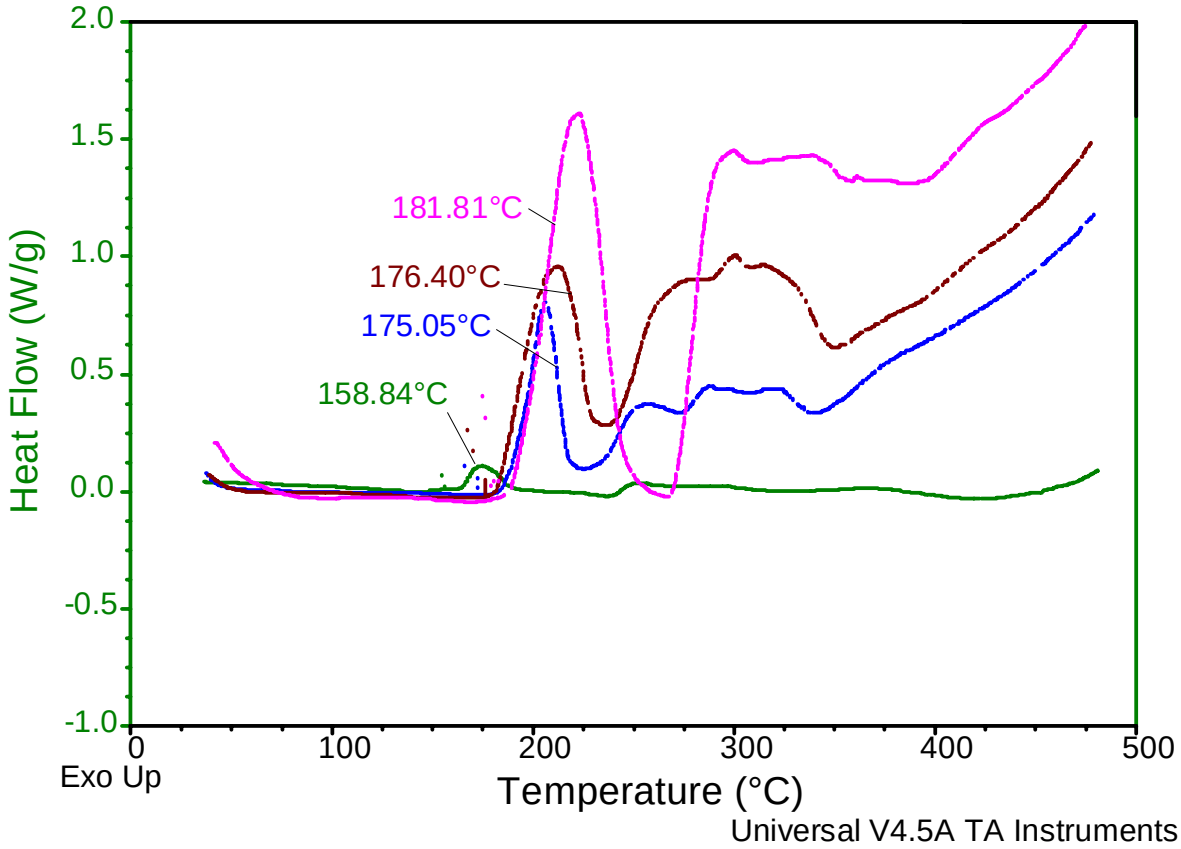
DSC Overlay: 1 °C/min., 5 °C/min., 10 °C/min., 20 °C/min.



In Differential Scanning Calorimetry (DSC) only exotherms were noted: low volatility of NF2

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Novel Nitrofurazan Plasticizer: NF2 Cont'd

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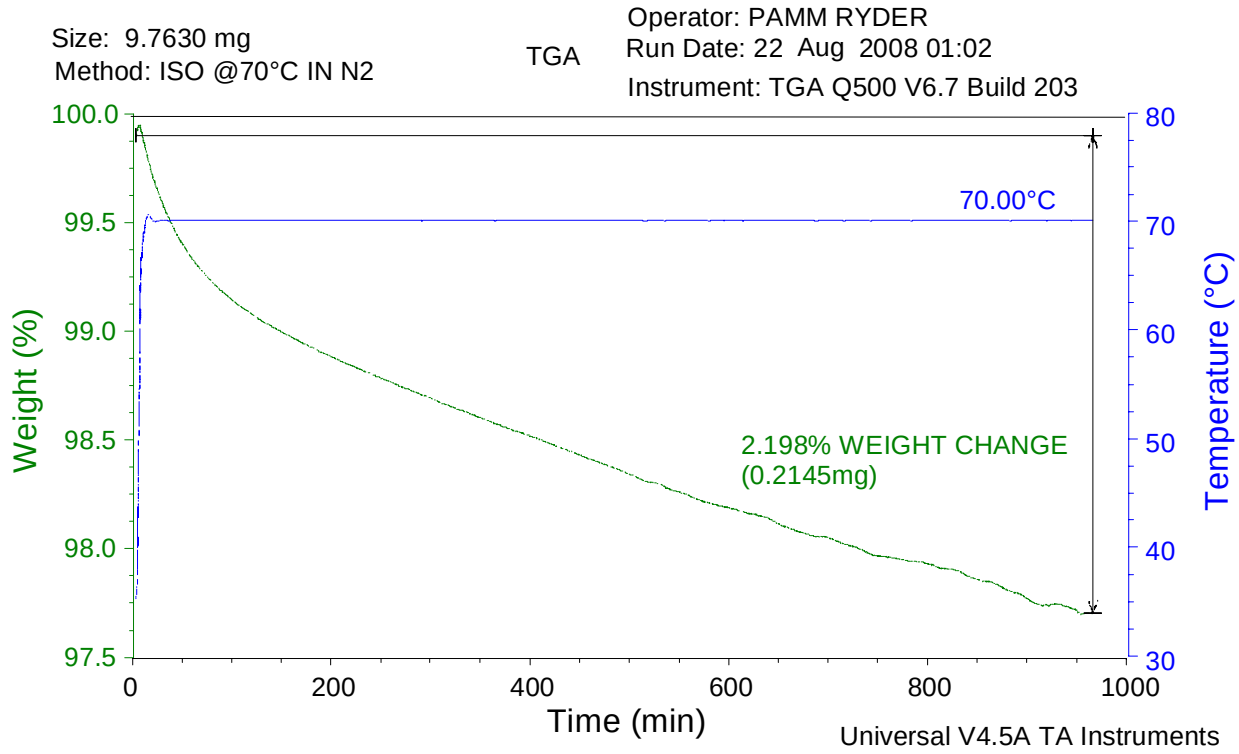
TGA ISO @ 70°C FOR 16 HRS



NF2 has low volatility: 2% loss in weight at 70 °C for 16 hrs

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Novel Nitrofurazan Plasticizer: NF2 Cont'd

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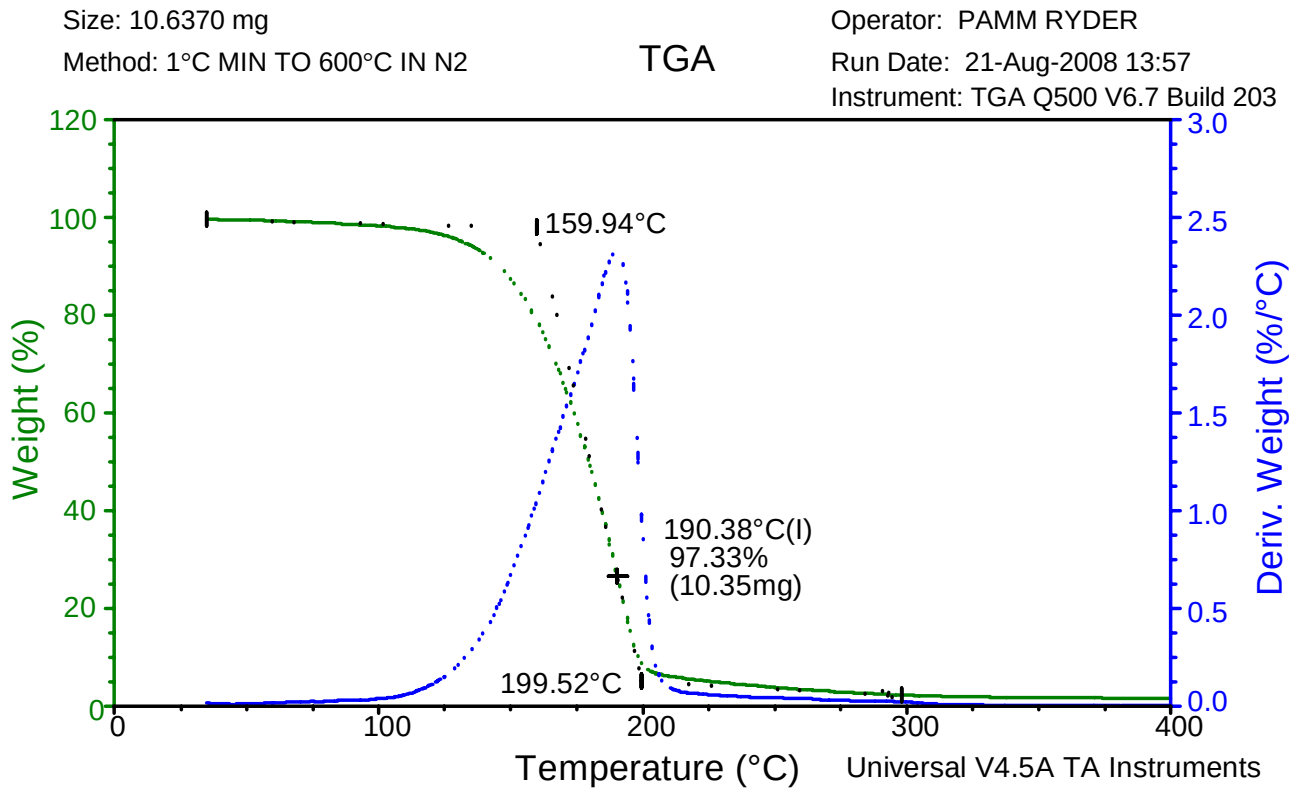
Thermal Gravimetric Analysis 1°C MIN



Onset in the weight loss for NF2 starts above 100 °C

Conclusions

- **NF2 has been successfully synthesized and characterized in a 40% overall yield**
- **NF2 synthesis used low cost precursors and was produced in high purity (>98%)**
- **NF2 Testing Results: insensitive (“green” category material)**
- **NF2 showed good thermal properties: it has good decomposition temperature and low volatility**
- **Additional work will be conducted - NF2 will be incorporated in propellant samples (work in progress at Aerojet)**

Acknowledgments

- **We gratefully acknowledge Missile Defense Agency (MDA) Small Business Innovative Research Program for funding this research**

- **We are grateful to Dr. Joseph Flanagan, Flanagan Research Company, Stanwood, WA for the insightful reviews of the paper**

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